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(54) Gas inlet orifice monitoring.

(57) The invention provides a method of monitoring the operation of a gas inlet orifice below the surface of a liquid under the action of positive gas pressure and with the formation of bubbles at the orifice, comprising the steps of collecting signals indicative of the pressure of the gas flowing through the orifice; removing from such signals the components thereof indicative of the mean pressure of said gas; and monitoring from the remaining components of such signals the pressure fluctuations thereby detected and caused by the formation of gas bubbles at the orifice.

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GAS INLET ORIFICE MONITORING

This invention relates to gas inlet orifice monitoring and more particularly to a method of and apparatus for monitoring or controlling the operation of a gas inlet orifice below the surface of a liquid such as molten metal in a metallurgical vessel.

According to the invention there is provided a method of monitoring the operation of a gas inlet orifice below the surface of a liquid under the action of positive gas pressure and with the formation of bubbles at the orifice, comprising the steps of collecting signals indicative of the pressure of the gas flowing through the orifice; removing from such signals the components thereof indicative of the mean pressure of said gas; and monitoring from the remaining components of such signals the pressure fluctuations thereby detected and caused by the formation of gas bubbles at the orifice.

The invention is based upon the recognition that except in certain unusual and identifiable circumstances gases blown into a liquid via an orifice produce bubbles of gas; and that such bubble production causes gas pressure fluctuations, which are usually small but detectable; and that these pressure fluctuations constitute a uniquely recognisable "signature" of a particular orifice operating under specific conditions, which can be monitored for changes brought about by variations in gas flow rate, orifice obstruction, and liquid density changes for example so that operation of that nozzle

can likewise be monitored.

In one embodiment the invention includes the steps of connecting the gas flowing through the orifice to a pressure transducer via two separate paths, in one of said paths filtering out pressure fluctuations caused by the formation of gas bubbles at the orifice, mutually opposing said two separate paths at said pressure transducer and monitoring the pressure fluctuations detected thereby.

The filtering in said one path may be achieved by forming that path from pipework having a length and cross-section determined from known criteria to damp and remove fluctuations of the frequency and magnitude which are determined to be related to the relevant bubble formation.

In an alternative embodiment of the invention removal from the signals indicative of the gas flowing through the orifice of the components indicative of the mean pressure may be accomplished by means of an arrangement incorporating a piezo-electric transducer. Thus an electrical circuit, incorporating a filter network to eliminate signals indicative of the mean pressure, may be connected to a piezo-electric interface device. Such an arrangement can have high sensitivity even at high mean gas pressures such as might arise when the orifice is small and/or gas flow rates very high.

The method of monitoring provided by the invention is

of especial applicability in relation to metallurgical process, in particular the production of iron and steel.

Thus in one embodiment of the invention the operation of gas supplying tuyeres for metal treatment vessels are monitored as hereinabove defined. Operation of the tuyeres can be controlled in dependence on monitored changes in fluctuations, particularly frequency and magnitude changes.

In a typical production plant installation, a system of two or more concentric pipes might be used, usually with an oxidising or exothermic gas passing through an inner pipe or annulus and an indothermic gas passing through the outermost annulus. Transducers would be fitted in the gas supply lines to detect the "signatures". In the case say, of a process in steel production in which agitation and stirring of the melt is carried out by below-melt injection of gases with perhaps only two gases involved, such as air and nitrogen, air would be supplied to the centre pipe with nitrogen passing through the annulus. The pressure "signatures" for the core would be obtained with a clear tuyere for a range of flow rates i.e. datum "signatures". During subsequent operation, the tuyere would be operated by adjusting the flow of the coolant (nitrogen) to obtain a dynamic thermal and hydrostatic balance at the tuyere exit so that a slight build up of metal occurred at the exit. This build up should be considered to be a sacrificial deposit which can be further eroded or built up

depending on small thermal inequilibria. The "signatures" of the core for this level of build up would also be determined and these would be the aim "signatures". In this way the aim and minimum level (datum) "signatures" for given core flow rates are established.

During the normal course of a processing cycle, the coolant flow will be adjusted to ensure that the desired core "signature" is obtained, e.g. a "signature" denoting a reduction in orifice area will initiate a reduction in coolant flow to restore the signature to the aim. Similarly, a move from the aim "signature" towards the datum "signature" will initiate an increased coolant flow.

By way of further explanation of this just mentioned arrangement it is to be noted that in the commercial operation of a tuyere the exit dimensions are variable up to the limit of the maximum of the pipe dimensions and this exit orifice size is controlled by adjusting the proportion of exothermic and endothermic fluids. An undue increase in the endothermic fluid will result in local overcooling of the tuyere exit with subsequent chilling of the liquid phase above the tuyere on to the tuyere. This growth can continue until the tuyere exit dimension is reduced to the extent that the tuyere is blocked. The exit size can therefore be controlled by adjusting the proportions of endothermic and exothermic fluids to achieve a satisfactory thermal balance

in order to produce an orifice with acceptable fluid dynamic characteristics. These fluid dynamic characteristics would be related to gas dispersion patterns and the preventions of liquid ingress into the tuyere.

In another embodiment of the invention the method of monitoring herein defined can be used to detect the junction level between two liquids of different densities. In metallurgical processes this may comprise the detection of the metal/slag interface in vessels.

Thus in one application of this embodiment the method of monitoring can be used in a blast furnace by detecting the level of liquid metal in the hearth and by selecting the position of the orifice using this to optimise the slag tapping operation. If the orifice is located just below the slag tapping notch, then when the liquid iron signature is detected at that point, slag tapping would commence resulting in only a minimum of slag being carried down on top of the metal to the lower metal notch. A similar orifice could be located at the metal notch level to detect the absence of metal and by inference, prevent tapping any slag at all through the notch.

In another application of this embodiment, the method of monitoring can be used in a BOS vessel by detecting the level of steel above the tap hole entrance to minimise slag carry over. If the sensor is located beside the tap hole, then the gas flow rate can be adjusted so that at some

predetermined value, penetration of the gas through the liquid steel into the overlying slag without any formation of bubbles will be achieved recognised by a total loss of "signature", giving time to rotate the vessel before slag is carried over.

In order that the invention may be more readily understood embodiments thereof will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a schematic view of apparatus for monitoring the operation of a tuyere;

Figure 2 is a typical "signature" produced by the apparatus of Figure 1; and

Figure 3 is a control diagram for a double tuyere.

Referring to Figure 1 it will be seen that there is illustrated a tuyere 1 having a consumable end 2 terminating in a nozzle 3 intended for connection into a metallurgical vessel below the molten metal surface therein.

A flush mounting diaphragm pressure transducer 4 is connected into the tuyere 1, the pressure diaphragm being connected in the tuyere flush to the gas stream at 5. By this means pipework resonance is avoided. The negative pressure tapping of the transducer is connected via low volume filter pipework 6 to the tuyere at 7. The filter pipework was selected by known criteria for filtering the relevant pressure fluctuations.

By connecting the transducer in this manner the operation is independent of overall pressure which is always balanced on each side of the pressure diaphragm, only signals representative of pressure fluctuations or bubble "signature" being transmitted.

One result of this is that the risk of damage to the transducer caused by dramatic changes in pressure is greatly reduced.

Signals from the transducer 4 are fed to a converter 8 which controls an oscillograph 9 providing a "signature" trace.

A typical "signature" trace is shown in Figure 2 at 10. As will be seen the amplitude of the "signature" is within a range of 100 mbar, when the gas pressure in the tuyere can be up to 7 bar. The time scale of the "signature" is indicated at 11.

In Figure 3 is shown schematically a possible control arrangement for a tuyere arrangement for metal processing comprising two concentric pipes, the inner or core pipe carrying an exothermic gas and the outer or annular pipe carrying an endothermic or coolant gas. At optimum operation a slight build up of solid metal at the tuyere nozzle will exist. The desired processing gas flow through the core pipe is measured at 12 and the base "signature" of the core, in particular the frequency of such "signature", at optimum operation is determined at 13. Thereafter during

operation the "signature", particularly its frequency, is monitored at 14. At 15 dependent on any frequency changes, coolant gas flow to the outer pipe is maintained constant, or reduced if the frequency decreases (indicating an increase in solid metal build up at the tuyere nozzle), or increased if the frequency increases (indicating a decrease in solid metal build up at the tuyere nozzle). By this means positive operational control of the tuyere function is achieved.

The arrangement of Figure 1 can also be regarded as illustrative of an arrangement for monitoring the level of the junction between the liquid metal in the hearth of a blast furnace and the overlying slag layer. In this case, for example, 1 will represent a pipe with an orifice 3 which may be arranged to be located just below the slag tapping notch. As the slag is tapped and the metal level approaches the slag tapping notch, the bubble signal at the orifice 3 will charge to indicate the transition from slag to metal and slag tapping can be terminated.

CLAIMS:

1. A method of monitoring the operation of a gas inlet orifice below the surface of a liquid under the action of positive gas pressure and with the formation of bubbles at the orifice, comprising the steps of collecting signals indicative of the pressure of the gas flowing through the orifice; removing from such signals the components thereof indicative of the mean pressure of said gas; and monitoring from the remaining components of such signals the pressure fluctuations thereby detected and caused by the formation of gas bubbles at the orifice.

2. A method according to Claim 1 including the steps of connecting the gas flowing through the orifice to a pressure transducer via two separate paths, in one of said paths filtering out pressure fluctuations caused by the formation of gas bubbles at the orifice, mutually opposing said two separate paths at said pressure transducer and monitoring the pressure fluctuations detected thereby.

3. A method according to Claim 2 wherein the filtering in said one path is achieved by forming that path from pipework having a predetermined length and cross-section such as to remove fluctuations in pressure of frequency and magnitude of the order of the relevant bubble formation.

4. A method according to Claim 1 including the steps of connecting the gas flowing through the orifice to a piego-

electric transducer, and passing the signal produced thereby through an electrical filter network to eliminate signals indicative of the mean gas pressure.

5. A method of monitoring the operation of a gas inlet orifice substantially as hereinbefore described with reference to the accompanying drawings.

6. A method of monitoring the operation of a below-melt tuyere incorporating a method according to any one of the preceding claims.

7. A method of detecting the junction level between two liquids incorporating a method according to any one of Claims 1 to 6.

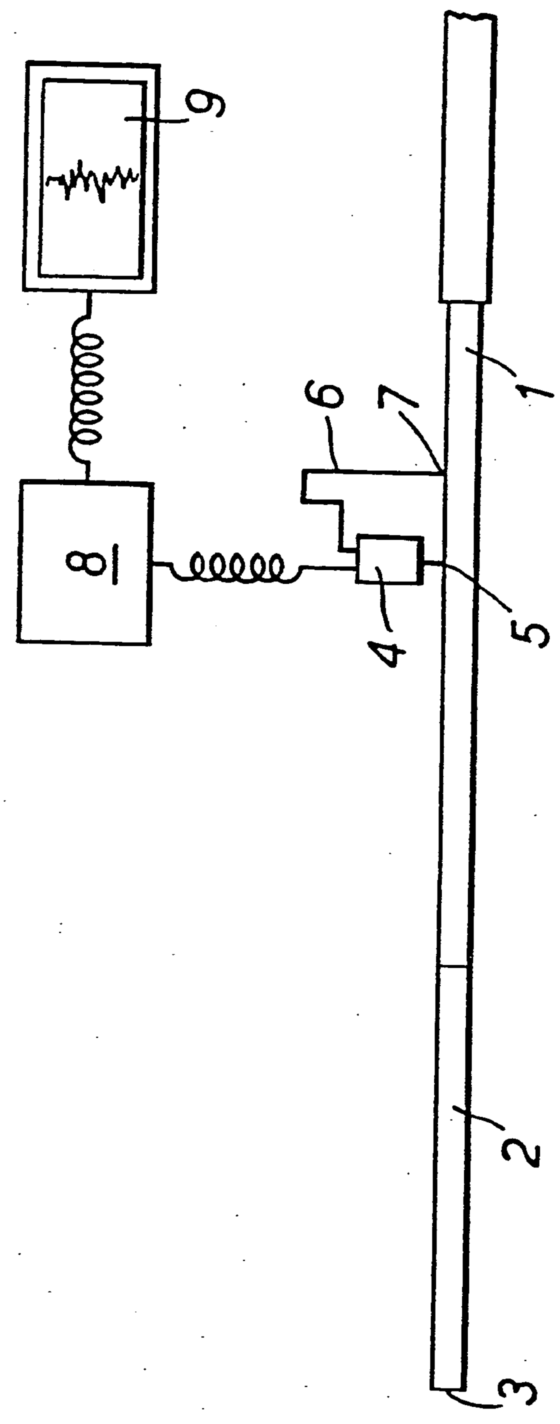


FIG.1.

FIG. 2.

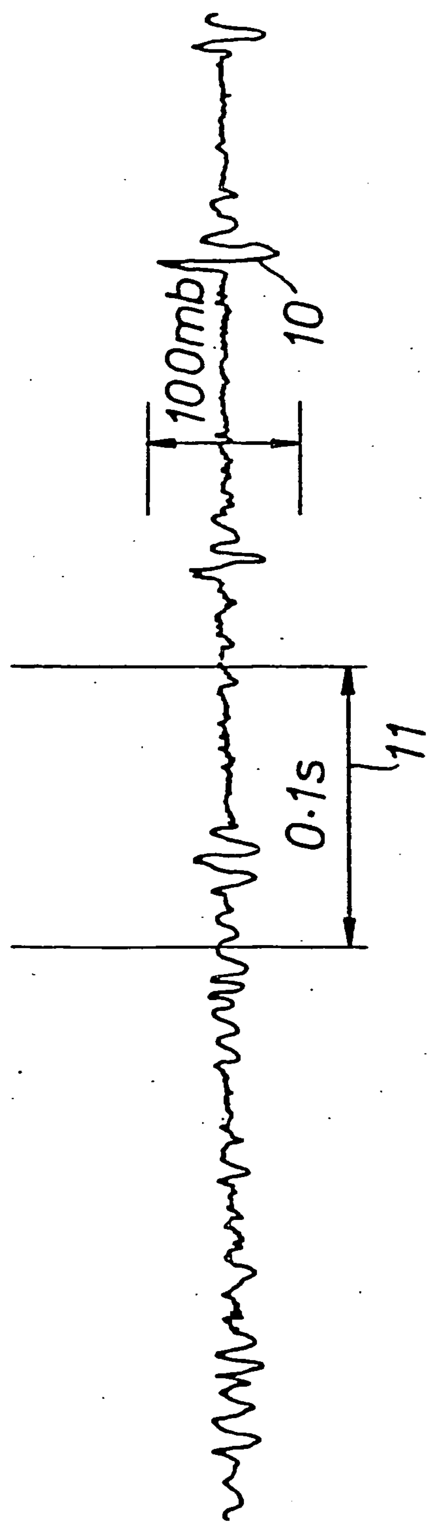
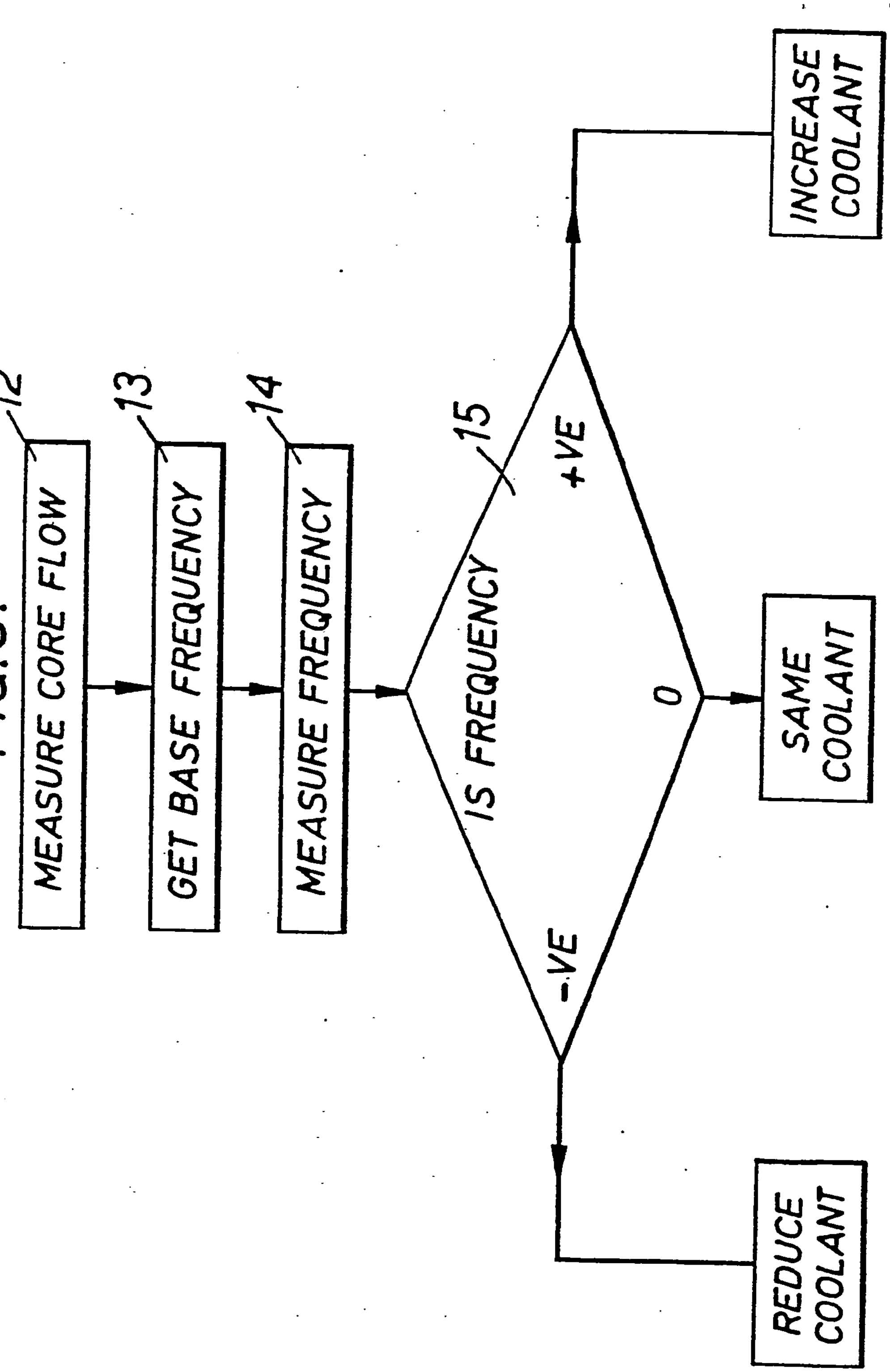


FIG.3.


12
MEASURE CORE FLOW
13
GET BASE FREQUENCY
14
MEASURE FREQUENCY
15
IS FREQUENCY
+VE
0
-VE
INCREASE COOLANT
SAME COOLANT
REDUCE COOLANT

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EUROPEAN SEARCH REPORT

Application number

EP 81 30 3556.5

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	GB - A - 2 003 591 (BRITISH STEEL) * pages 2, 3 * --	1	C 21 C 5/30
A	GB - A - 1 356 225 (ALLEGHENY LUDLUM INDUSTRIES) --		
A	GB - A - 1 447 642 (USS ENGINEERS AND CONSULTANTS) --		
A	GB - A - 1 253 581 (EISENWERK - GESELLSCHAFT MAXIMILIANSHÜTTE) --		TECHNICAL FIELDS SEARCHED (Int. Cl.³) C 21 C 5/30
A	DE - B2 - 2 326 754 (EISENWERK-GESELLSCHAFT MAXIMILIANSHÜTTE) --		
A	Patents Abstracts of Japan Vol. 1, No. 132, 31 October 1977, page 5960E77 & JP - A - 52 - 66466 ----		

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	28-10-1981	SUTOR

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